**CMPG-767/CMPT-477 Image processing and Analysis**

**Project 4**

**1 (25 points for graduate students; 50 points for undergraduate students).** Design a function utilizing rank order EV filtering (Mean). This function shall accept a noisy image (2D array) and return a filtered image (2D array).
Take into consideration that a suboptimal value of the $\varepsilon_v$ (EV) is $\sigma$ (standard deviation) of a noisy image. Use your function from Project 1 to evaluate $\sigma$.
Do not forget about padding your image using its mirroring to process image's borders.

You may fix the filter window size 3x3 or design a function for the general case (arbitrary filter window size). In the latter case include a window size as an additional parameter in you function and take into consideration that you need to pad your image accordingly.
The second option (adaptation of the function to any window size) **will give you 15 points of extra credit score**.

**2 (20 points for graduate students; 45 points for undergraduate students).** Add additive Gaussian noise like you did in Project 2 (noise should have standard deviations of $0.2\sigma$ and $0.3\sigma$) using the functions, which you designed working on your Project 2 or use noisy images from the Project 2 if you stored them.

Filter your noisy images using the rank order EV filter. Use the function, which you designed.

Evaluate RMSE/PSNR for the filtered images and compare the results to the ones which you got using linear filters in Project 2.

**3**. (**required for graduate students – 30 points; extra credit for undergraduate students (extra credit works only in conjunction with Task 4 – 30 points)**

a) Design a function utilizing rank order ER filtering (Median) for a fixed 3x3 window size. This function shall accept a noisy image (2D array), parameter $\varepsilon_r$ and return a filtered image (2D array).
   Take into consideration that $\varepsilon_r$ can be equal to 1, 2, 3 or 4 for a 3x3 window. Do not forget about padding your image using its mirroring to process image's borders.
b) Design a function, which utilizes impulse noise filtering with the differential rank impulse detector - DRID (use your function from Project 3) and rank-order ER filter for filtering of detected impulses instead of median filter.

**4. (required for graduate students – 20 points; extra credit for undergraduate students (extra credit works only in conjunction with Task 2 – 20 points)**

Corrupt an image with random impulse noise by creating two noisy images – with 5% and 10% corruption rate. Use your respective function from Project 2.
Filter your noisy images using your function with the DRID detector and median filter from Project 3.
Filter the same images using your function with the DRID detector and rank-order ER filter, which you designed in Task 3 of this project.

Evaluate RMSE/PSNR for the filtered images and compare the results to the ones which you got using median filter with DRID in Project 3.

Try to find a value of $\varepsilon_r$, which makes it possible to get better results with the DRID detector in conjunction with the rank order ER filter than in conjunction with median filter.

**5 (5 points).** Prepare a brief technical report containing your RMSE/PSNR values, processed images and your conclusion.
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**6.** Turn in your source code, report, and resulting images in a single zip file.